National Unmanned Systems Experimentation Environment (NUSE2) Field Experiment – F.E. Warren AFB

Good Afternoon,

I'm Kevin Hodges, Program Manager, for AFRL's Remote, Detection, Challenge and Response (REDCAR) project and today I'm going to discuss with you the National Unmanned Systems Experimentation Environment (NUSE2) sponsored experiment conduct and F.E. Warren AFB.

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
01-08-2006	Conference Proceedings POSTPRINT	01-11-2005 - 01-08-2006

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
National Unmanned Systems Experimentation Environment (NUSE2) Field Experiment - F.E. Warren AFB	F08637-03-C-6006

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
63112F

6. AUTHOR(S)	5d. PROJECT NUMBER
Hodges, Kevin	4918

5e. TASK NUMBER
L4

5f. WORK UNIT NUMBER
Q240FA5Z

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Air Force Research Laboratory, Materials and Manufacturing Directorate, Airbase Technologies Division, Force Protection Branch 139 Barnes Drive, Suite 2 Tyndall AFB, FL 32403-5323	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Air Force Research Laboratory Materials and Manufacturing Directorate 139 Barnes Drive, Suite 2 Tyndall AFB, FL 32403-5323	AFRL/MLQF
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	AFRL-ML-TY-TP-2006-4556

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution Statement A: Approved for public release; distribution unlimited.
AFRL/MLQ Public Affairs Case #06-070.

13. SUPPLEMENTARY NOTES
Document contains color images. Published in conference proceedings for Association of Unmanned Vehicle Systems International (AUVSI) Unmanned Systems North America 2006 Convention, 28-31 Aug 2006 in Orlando FL.

14. ABSTRACT
The Air Force Research Laboratory, Robotics Research and Development Group have developed and demonstrated a proof-of-concept robotic perimeter security system for the USAF Force Protection Battlelab. The REDCAR project (Remote, Detection, Challenge, and Response) evaluated the utility of mobile robotic systems for installation security missions during a series of operational demonstrations in November of 2005 at F.E. Warren AFB. For the REDCAR project, AFRL has developed a hight-speed ground robotic system (SCOUT) and integrated existing robotic platforms (MDARS-E and Matilda) with the USAF Integrated Base Defense Security System (IBDSS).

15. SUBJECT TERMS
NUSE2, unmanned systems, proof-of concept, experiment

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Walt M. Waltz
U	U	U	UU	20	19b. TELEPHONE NUMBER *(Include area code)*

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

REDCAR
Project Overview

Force Protection Battlelab Initiative

➢Demonstrate the benefits of unmanned systems for the security force operations with the primary mission of perimeter defense of Air Force installations and forward deployed units

➢Network of robotic platforms integrated with existing security force Integrated Base Defense Security System (IBDSS) sensors

➢The AFRL Force Protection Branch, Robotics Research and Development Group is the technical developer and program manager for the REDCAR initiative

➢Operational requirements for REDCAR are in the Integrated Base Defense 2020 Concept of Employment (IBD2020 CONEMP)

Approved for Public Release

REDCAR began as a Force Protection Battlelab Initiative to determine the feasibility of unmanned systems conducting primary defense missions Air Force installations, sites and forward deployed units.

REDCAR is not a platform developed by any single lab or company. It is a systems of JAUS compliant platforms on a common network controlled through a single operator control unit, (used) with an Integrated Base Defense Security System

The FPBL enlisted the services and capabilities of the AFRL Force Protection Branch, Robotics Research Group as the tech developer and program manager for this initiative.

Force Protection Branch

Air Force Research Laboratory
Materials and Manufacturing Tech Directorate
Airbase Technologies Division

Operations Support Branch (MLQO)

Airbase Sciences Branch (MLQL)

Deployed Base Systems Branch (MLQD)

Force Protection Branch (MLQF)

Robotics Research Group Mission

➢ The Air Force's *Robotics Research Group* conducts research and development of advanced robotic technologies and systems to protect, support, and augment the warfighter in the accomplishment of <u>dirty</u>, <u>dull</u>, <u>dangerous</u>, and <u>impossible</u> missions.

➢ **Robotics Research Group**

➢ Security Engineering and Explosives Research Group
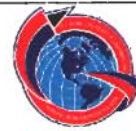
➢ Range Operations and Support Group

Approved for Public Release

When most people hear AFRL they often ask Wright-Patt? AFRL HQ is located at Wright- Patterson AFB, OH but our detachment the Airbase Technologies Division, under the Materials and Manufacturing Directorate is located at Tyndall AFB near Panama City, Florida.

REDCAR
Participants

USAF
➢ Force Protection Battlelab - FPBL
➢ Air Force Research Laboratory
   AFRL/MLQF Robotics Research Group
➢ Electronic Systems Center -- ESC/FD

USA
➢ Program Manager - Force Protection Systems - PM-FPS

USN
➢ Space & Naval Warfare Systems Center
   - SPAWAR Unmanned Systems Branch

Approved for Public Release

Naturally we did not complete this effort on our own. In addition to our organization and the FPBL we had the assistance for the Electronic System Center from Hanscom AFB, PM-FPS and SPAWAR were instrumental in providing support from the MDARS program.

REDCAR
Eglin Proof of Concept Demonstration Results

- High Speed Assisted Teleoperation to 40 mph
- Tiered response with lethal and less than lethal weapons
- JAUS Network of unmanned mobile systems
- Integrated with USAF Tactical Area Security System (TASS)
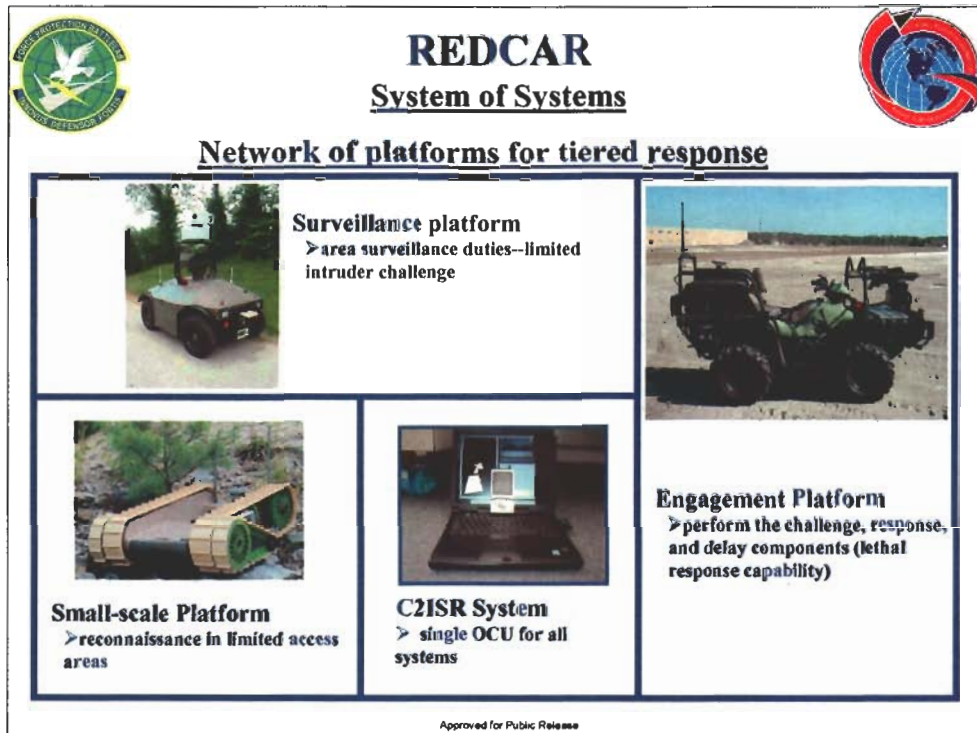
⬤ Accomplished   ◯ Partial Success   ⬤ Unsuccessful

Approved for Public Release

These were the four main objectives of the proof of concept demonstration and as the slide depicts, we were successful in accomplishing each objective. Of particular note was the development of high speed assisted teleoperation at high speeds to aide system operators in controlling vehicle movements.

Approved for Public Release

REDCAR
System of Systems

Network of platforms for tiered response

Surveillance platform
➤ area surveillance duties--limited intruder challenge

Small-scale Platform
➤ reconnaissance in limited access areas

C2ISR System
➤ single OCU for all systems

Engagement Platform
➤ perform the challenge, response, and delay components (lethal response capability)

Approved for Public Release

Earlier I said REDCAR was not a platform but system of JAUS compliant platforms, here is a great example of that concept.

The MDARS platform served as the surveillance platform for the experiment by performing random patrols and static sentry missions

The small scale platform, either a JAUS compliant PACKBOT or Matilda, was not used in the FE Warren experiment because the experiment area did not afford the opportunity to exploit the small platform capabilities. However, the mission of these platforms is to conduct surveillance and recon of areas inaccessible to the larger platforms.

The engagement platform was the AFRL developed Scout vehicle, a military variant of the Polaris Sportsman ATV with surveillance, non-lethal and lethal payloads.

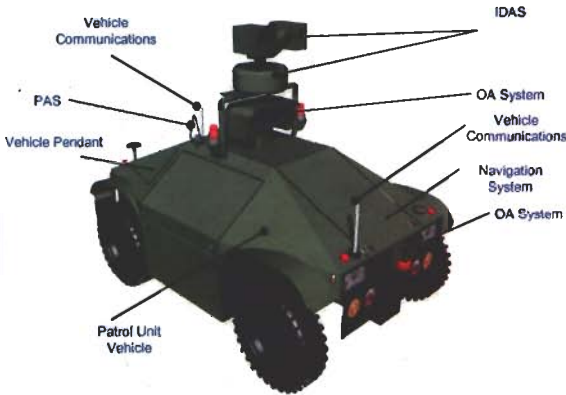The C2ISR System provided a single operator control unit for all systems

Brief this slide verbatim

REDCAR
Engagement Platform

SCOUT
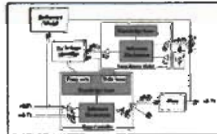
Engagement Platform
- Perform the challenge, response, and delay components
- JAUS compatible REDCAR SCOUT robot built by AFRL
- Traverse over rough terrain, and through heavily wooded areas
- Waypoint navigation up to 20mph – with obstacle avoidance.
- Teleoperated motion at high speed = 40 mph sprint
- Primary patrol mode will be on pre-surveyed routes
- RSTA system payload with EO, IR, Night Vision, Laser Rangefinder
- Lethal & non-lethal weapons systems
  - NLW: Pepper Spray Fogger with marking dye
  - LW: Precision targeted rifle M16A2

Obstacle Avoidance   Velocity Controller

Approved for Public Release

Brief this slide verbatim

F.E. Warren Experiment
9 – 16 May 05

- National Unmanned Systems Experimentation Environment (NUSE2) experiment to perform semi-autonomous physical security in relative environment with on-duty security forces

- No NUSE2 site has on-duty security forces performing physical security protection mission – F.E. Warren selected

- Meets AFRL need for robust operational experiment
    - Determine research requirements for advanced robotic behaviors
    - Determine research requirements for machine/human interface
    - Produce data for SF planners to develop CONOPS and operational requirements

Approved for Public Release

Shortly after the proof of concept demonstration we were asked to conduct a demonstration under the NUSE2 program. After evaluating our need for an experiment in a relative environment we began coordination for access to F. E Warren AFB to conduct an operational experiment with the intended user community.

We planned for the experiment to serve as the center point to focus our R&D efforts and to provide SF planners data necessary for realistic CONOPS for unmanned systems and to serve base line for operational requirements

F.E. Warren Experiment

- Experiment Plan
    - Deploy AF Security Forces Tactical Automated Security Systems (TASS) with Ground Based Radar as stand-off detection system near Weapons Storage Area
    - Provide orientation training Security Forces Squadron personnel as system operators
    - Integrate platforms into existing security force structure to conduct stand-off detection and challenge missions
    - Capture data from experiment to guide research and development plans for robotic platform capabilities

Approved for Public Release

Our approach for the experiment was simple and straight forward, we needed to operate in as near a "normal" operating environment

- We placed unattended ground sensor in the area surrounding the weapons storage area to provide stand off detection

- The local security forces squadron provided operators to us during each tour of duty and after a little orientation on the system, SF personnel operated the platforms under the supervision of AFRL personnel

- We blend the robotic systems into the day-to-day security operations along side posted security forces

- And at the end of the experiment we established a guide to lead further research and development efforts based on early user feedback and input.

11

F.E. Warren Experiment

Notional Experiment Site
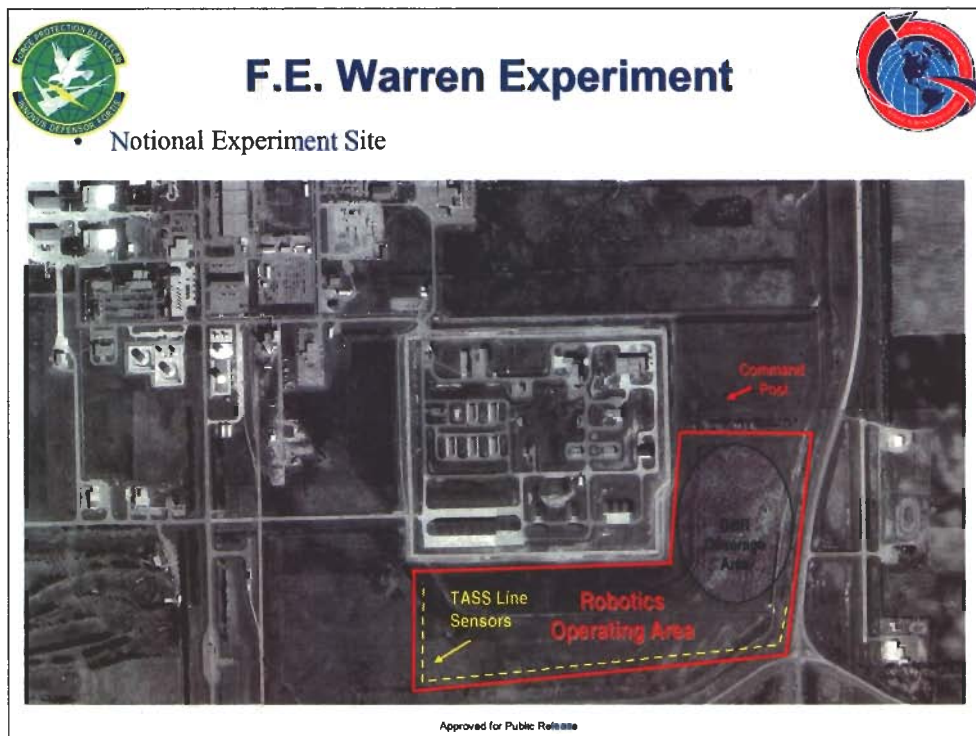
Due to security concerns by the host installation, I am unable to show you the actual area we conducted the experiment, however thanks to the internet I am able to show you a notional depiction of a REDCAR experiment site .

Essentially you have and area protected by on-duty response forces and sensor systems typically along fence lines marking legal boundaries

We added stand-off detection through to use of tactical sensors and ground based radar and added stand-off response and challenge through the introduction of remotely operated systems

F.E. Warren Experiment
How Did We Do?

- Exercise Response:
  - Stand-off Detection and Assessment:
    - One exercise aggressor identified during major response force exercise using surveillance payload approximately 605 meters from platform
      - Directed Security Forces to aggressor location – no friendly forces lost
    - Ground radar detected exercise aggressor crawling toward restricted area; used surveillance infrared payload to locate aggressor and direct security forces to interdict—aggressor in custody of Security Forces 350 meters from restricted area perimeter
    - Intercepted intruder along Northwest boundary of the restricted area; challenged suspect and delayed intruder until arrival security force

Approved for Public Release

During a major force-on-force exercise we were able to use our surveillance to detect an exercise aggressor at a distance of approximately 605 meters from our platform. We then directed responded forces to the excise aggressors location.

Our ground radar detected a target approaching the area we were protecting. We dispatched the Scout platform to assess the alarm. Using our IR surveillance payload we detected an exercise aggressor crawling towards the restricted area and directed security forces to intercept. The aggressor was in SF custody 350 meters from the restricted area boundary. This represents a 350% increase in detection, assessment and response capability over current technology.

The last example of our success was demonstrated when we intercepted an exercise intruder moving along the restricted are perimeter, we were able to perform a remote challenge of the suspect and placed in a position of disadvantage until security force could arrive.

F.E. Warren Experiment
What Did We Learn?

• Research and Development Areas:

   – Advanced Robotic Behaviors
     • Navigation
     • Alarm Response
     • Diagnostics/Maintenance/Repair
   – Human/Machine Interface

Approved for Public Release

-The recurring lesson learned from our experiment was these systems require advanced autonomous capabilities in order to be effective in security force operations. The idea of an operator sitting behind an operator control unit does not excite anyone in the user community. These systems must complete a majority of their assigned duties independent of operator input in order to increase ease of operation.

F.E. Warren Experiment
What Did We Learn?

- Research and Development Areas:

  - Advanced Robotic Behaviors
    - Navigation
      - World modeling (update/learn changes in environment)
      - Dynamic environment operations (OA)
      - Communication loss navigation behaviors

-In the area of advanced robotic behaviors

-Navigation

> -Unmanned systems developed for day-to-day operations in dynamic environments need the capability to update or lean changes in the environment as the systems traverse the operating area and share this information is all systems on the network. The ability to record obstacle and terrain data will greatly assist operators in efficiently employing these systems and allow systems to independently determine the safest, quickest route from point A to point B. .

> - Obstacle Avoidance needs to migrate toward "obstacle classification"…systems need to be able to determine the "traversability" of perceived obstacles. "Vegetation vs. boulder decision making".

> - The last area in navigation to consider is what behaviors do we want robotic systems to possess when communications are lost. This is more of a "policy" or procedure instead of a technology challenge however early decisions on policy will make the selection of technology solutions a little easier.

F.E. Warren Experiment
What Did We Learn?

- Research and Development Areas:
  - Advanced Robotic Behaviors (Continued)
    Alarm Response
      - Situational awareness (what alarm was triggered)
      - Alarm assessment (self-path planning to assess sensors, look-at-commands and go-to-commands; what is the assessment behaviors for the platform, autonomous challenge behaviors)
      - Hostile engagement (non-lethal/lethal with assisted target acquisition and tracking/IFF)
      - Self protection
    - Diagnostics/Maintenance/Repair
      - Refuel/recharge
      - Graceful Failures (operate safely as failures occur/self-healing)
      - Redundant systems

-In the area of Alarm response we rapidly discovered the need for autonomous alarm investigation behaviors to assist platform operators

-Integration into exiting alarm systems is necessary to provide the situational awareness to determine what sensors of the security system have been triggered and what assessment priority as been assigned.

-Alarm response behaviors need to include self-path planning for the systems to determine the fastest response route to intercept an intruder prior to the intruder reaching the protected area. Platforms must also be able to conduct autonomous challenge of intruders and possess the ability to keep itself between the resource being protected and the intruder to provide maximum delay to the area perimeter. (LSU – Automated Target Engagement Methods)

-Systems intended for defensive and offensive operations with lethal capability need Assisted Target Acquisition and affordable engagement on the move capability of moving targets. (P2SUMS) In addition, in fog of war especially in limited visibility, Identify, Friend or Foe (IFF) technology will be an absolute must.

-And lastly platforms providing physical security response capability will need to have autonomous self-preservation behaviors to prevent unauthorized user from gaining access to the vehicle.

F.E. Warren Experiment
What Did We Learn?

- Research and Development Areas (cont):
  - Human/Machine Interface
    - Cognitive task analysis and human effects studies to determine ergonomics, information/visual presentation, audio interface and operator saturation

Approved for Public Release

In the area of Human/Machine interface once again the level of autonomy built into systems we have a large role in how information is presented. For the average user information needs to be minimized to the amount necessary for vehicle and payload operation.

Visual information must be presented from the user intuition perspective vs. the developer perspective.

Example: Users preferred the view on the left vs. the view on the right while driving the vehicle.

And lastly how information is two much and when does operator saturation occur. Simply we are often asked how many robotic systems can one operator control? Regardless of network capability one operator can control only one robot in teleop mode at a time.

F.E. Warren Experiment
What Did We Learn?
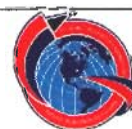
- Research and Development Areas (cont):
  - Platform Operational Requirements
    - Highly agile – skid steer/four-wheel steering, low CG, high speed 40+
    - High performance off-road suspension
    - Commercially light weight armor – NIJ Standard Level IV
    - Redundancy for communications system-self selecting for best performance
    - Although custom vehicle is probable, maximize commercially available parts where possible
    - Mission duration of 12-hours minimum; silent operation for payloads 6-hour minimum-self-status for recharging battery powered payloads
    - One vehicle type most likely will not meet all needs depending upon topography, weather and operational constraints of the installation

Brief this slide verbatim

F.E. Warren Experiment

Questions?

Approved for Public Release

19